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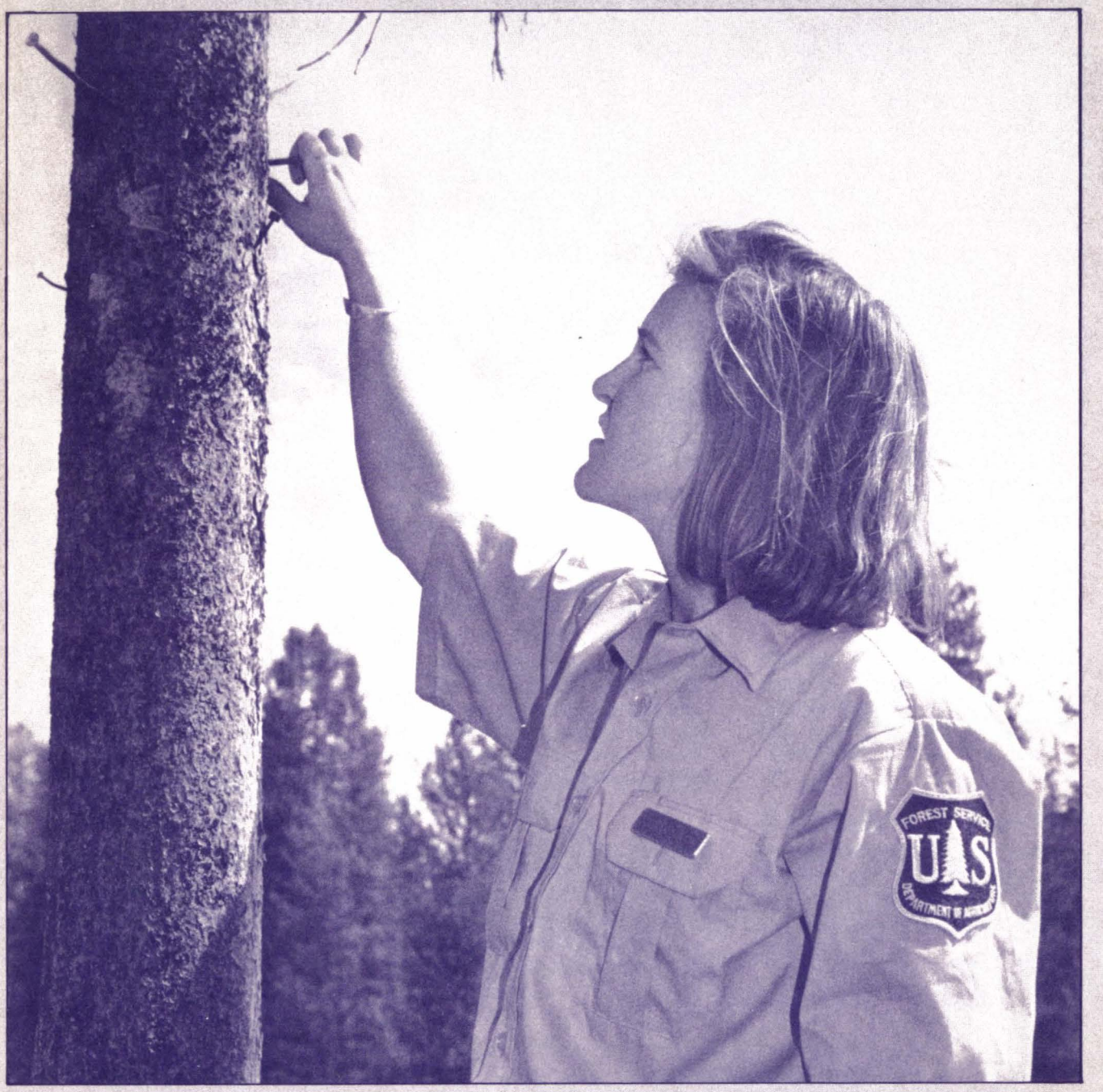
**Forest Service**

# Forestry Research West

September 1992



A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

# Forestry Research West

## In This Issue


page

*Soft Paths*: a partnership for wilderness research application 1

Managing for salmonid habitat 7

Predicting the demand for grazed forages in the U.S. 12

Pheromones help to control bark beetles at Torrey Pines 17

New from research 21


## Cover

*A new book is out, titled "Soft Paths", promoting a land ethic that can reduce visitor impacts on wilderness areas while preserving personal freedoms for wilderness visitors. Here, Wilderness Ranger Kim Corette looks at human impacts of driving nails into trees at a campsite in the Bob Marshall Wilderness in Montana. Details begin on page* 1

## To Order Publications

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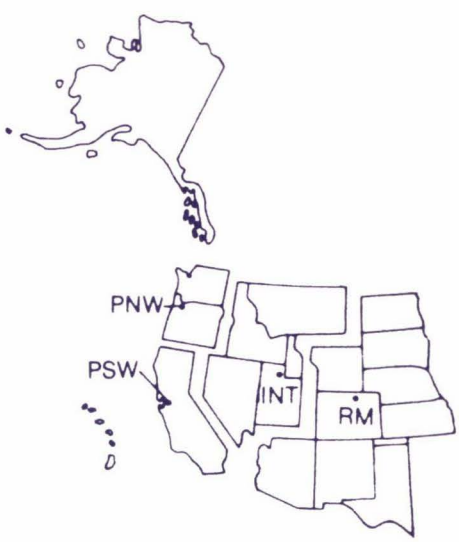


# *Soft Paths*: a partnership for wilderness

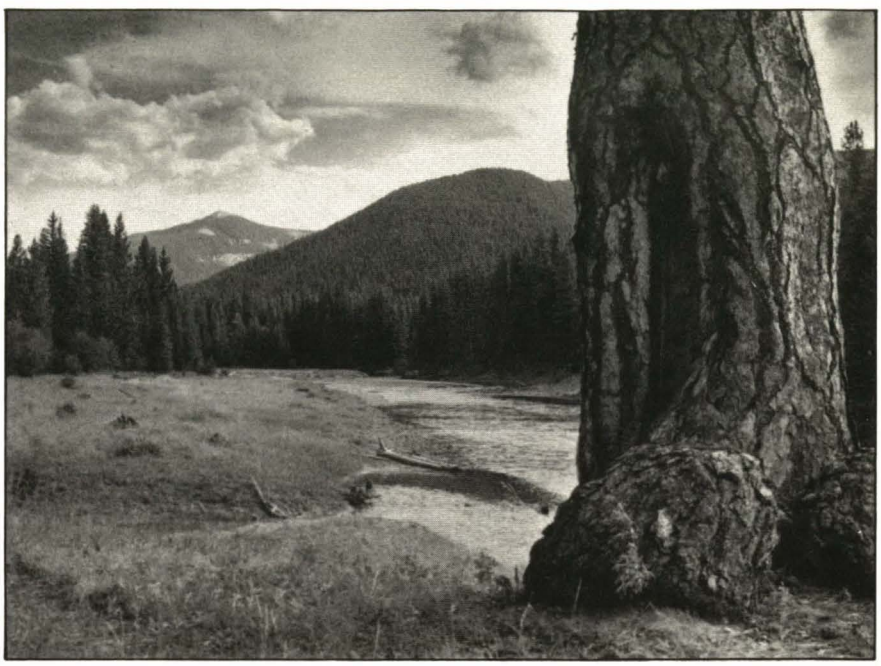
by David Tippets
Intermountain Station

Wilderness Researcher David Cole joined the National Outdoor Leadership School (NOLS) in a bold partnership to go beyond ordinary concepts of research application to changing human nature, because human nature is changing the nature of wilderness.

Less creative and more timid scientists might have been content to see research results turned into management guidelines, and eventually rules and regulations. But Cole and NOLS shared a belief that rules aren't the best way to reduce human impacts in wilderness, and instead attempted to eliminate the need for more rules by teaching a land ethic based on both Forest Service research and over 20 years of experience by NOLS instructors.

"Rules are for fools," NOLS founder Paul Petzoldt preached, inspiring outdoor education based instead on developing understanding and good judgment.

"Things aren't that simple in life," NOLS instructor Bruce Hampton said recently during an interview. "Sooner or later you'll get in trouble if all you do is follow rules." NOLS hired Hampton to work with Cole in writing a book, *Soft Paths*, to teach a land ethic that would reduce impacts in wilderness. NOLS also displayed the "Soft Paths" land ethic in a video released in the spring of 1991.



*Some enduring camping impacts in wilderness, such as the scar on this ponderosa pine where Indians stripped the cambium layer of the bark for food, show how long high-impact camping practices can linger for future generations to see. Fire history research around these popular Indian campgrounds also reveals that frequent wildfires originating from these camps created the open park-like communities that make these river benches along the Flathead River in Montana popular with modern horse campers.*

*Soft Paths* may have come too late for wilderness where impacts are already too extreme, such as the lake in Yosemite National Park that already has 300 fire rings around it, making the lakeshore one huge scar.

"Over the past half century wilderness use has skyrocketed," Cole said recently, while talking about the need for a land ethic. "Wherever one person walked and camped in 1950 more than 15 do today."

Compounding the impact of increased use on small areas, people tend to concentrate in the less than 10 percent of the backcountry that is close to water.

## A question of freedom

"A simple equation exists between freedom and numbers: the more people, the less freedom," Hampton and Cole quote Royal Robbins in their book.

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*You can reduce impact on the wilderness by breaking with unwise traditions and building your fire on a mound of mineral soil, rather than in a pit or fire ring. A piece of heat-reflecting fire shelter material used as a base is an application of technology that can further reduce campfire impacts. (NOLS/Will Waterman)*

When freedom is lost in wilderness, the essential quality of a wilderness experience is degraded. If the tendency of government to govern by laws, rules, regulations, or administrative orders is applied liberally in wilderness, it damages the experience for both ethical and unethical users. Perhaps nowhere can it be better said that the government that governs least governs best. This understanding gives spreading the "Soft Paths" land ethic a sense of urgency, because the goal is to preserve disappearing personal freedom, as well as the wilderness resource.

"There isn't much you can do once a regulation is imposed," Hampton said, admitting that once serious resource damage begins there are few alternatives.

If the "Soft Paths" land ethic is embraced by enough wilderness users, visitors can feel that they are free to use the wilderness within the bounds of their own judgment.

## Wilderness research and education

Forest Service Research and NOLS joined forces in 1985 after NOLS invited several recreation researchers to a retreat to discuss better wilderness management. Retreat participants learned that they shared great interest in low-impact practices. After that meeting the Intermountain Research Station and NOLS decided to pool their resources.

Before becoming Project Leader for the Station's Wilderness Management Research Work Unit in Missoula, MT, Cole contracted research for both NOLS' and the Station. The "Soft Paths" land ethic is based to a large extent on work by Cole and other Forest Service researchers. Each chapter in the book has a "Further Reading" list that includes research publications and technical articles that create a solid scientific foundation for the proposed land ethic.

The book and video complement more-technical research publications and should share space with Station publications on bookshelves of wilderness managers. *Soft Paths* can lead managers to more-technical information to help them resolve specific problems—making technology transfer from research to management easy.

The General Technical Reports, INT-176, 230, and 265 are especially useful and are written to serve managers. Cole organized INT-265, *Low-Impact Recreational Practices for Wilderness and Backcountry*, as a manager's reference handbook, making information on specific practices easily accessible without requiring managers to wade through lots of technical materials.

*Managing Wilderness Recreation Use: Common Problems and Potential Solutions*, INT-230, is equally "user friendly" for managers. INT-176, *The Limits of Acceptable Change (LAC) System for Wilderness Planning*, is another of the wilderness research publications written for managers. These research publications are written for easy reading, but don't approach the palatability of *Soft Paths*, a book most managers could read for pleasure.

"Cole has a good eye for taking technical information out," Hampton said, relating that Cole reduced the technical information in the draft by 20 percent, unlike some scientists who have too strong an interest in the details to simplify their work. But even though *Soft Paths* is simplified, it still has lots of meat on its bones.

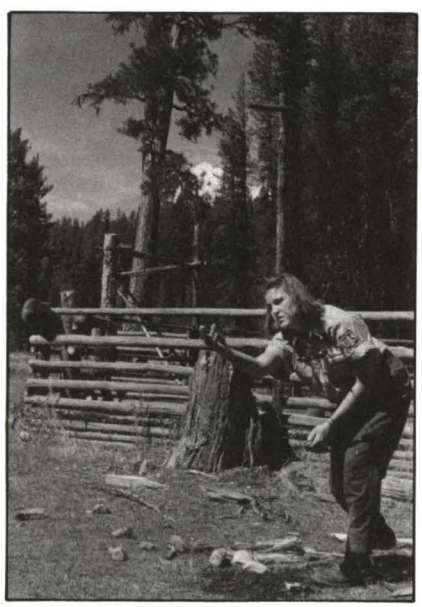
"Many agency pamphlets on low-impact practices were below the interest and intellectual level of wilderness users," Hampton said. "We wanted to hit a niche between technical publications and trailhead pamphlets."

## Judgment versus rules

In keeping with the NOLS philosophy of teaching good judgment rather than rules, *Soft Paths* discusses conflicts that wilderness travelers can only solve with good judgment on a case-by-case basis. It debunks unwise traditional wisdoms. It challenges things that defy common sense.

"When we say things are wrong, it's not that they are wrong all the time," Cole explained, "but that they are not always right."

"Always camp at least 200 feet from water," wilderness regulations often demand, as an example of rules that can backfire on managers. But sometimes the best low-impact camping spot is at the water's edge, below the high-water line of lakes or rivers. Beaches and sandbars are usually durable and high water erases signs of human presence.



*Wilderness Ranger Kim Corette rehabilitates a fire ring built next to an outfitter's corral to discourage campfires at the site.*

Common sense would indicate that the more use, the more impact--not so. Research reveals that most of the impact that occurs on a campsite occurs in the first few times it is used. *Soft Paths* gives readers information so they can better decide whether to camp at an existing site or look elsewhere.

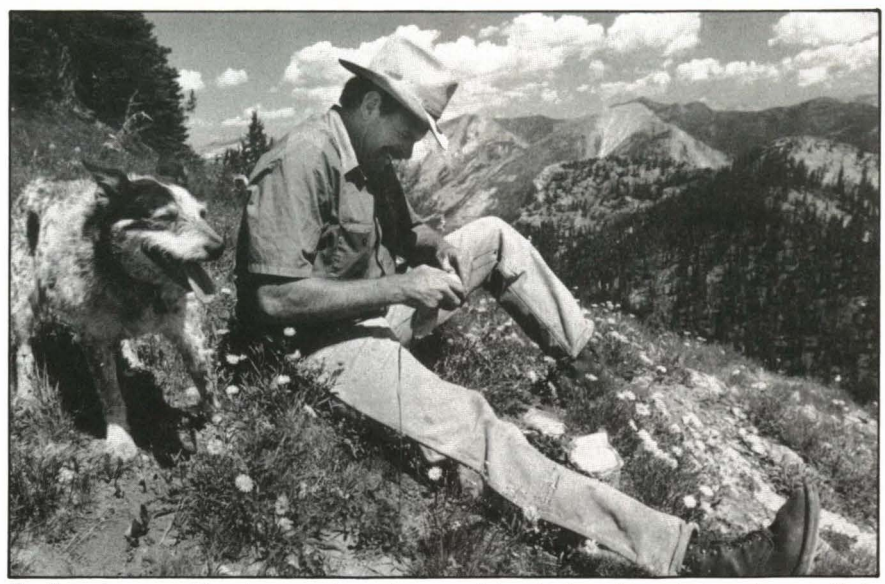
*Soft Paths* enhances common sense with the application of science, such as in the book's discussion of desert sanitation. Human feces don't decompose in arid inorganic soils free from the microorganisms that break down waste in humid forests. The authors point out that heat is the only natural agent available to kill human fecal pathogens in the desert environment. Without this understanding, common sense might dictate burying waste deeply in the soil, but with this knowledge, common sense suggests burying feces in catholes so shallow that the desert sun can fry the germs. Cole and Hampton also explain when it's best not bury feces at all.

Perhaps in no other situation does the wilderness user have greater personal responsibility to exercise judgment to prevent government regulation than when traveling in the backcountry with a dog. Dogs are already banned from the backcountry of most national parks and officially discouraged most other places, as the consequence of thoughtless behavior by dog owners in the past who lacked knowledge, good judgment, or control of their pets. Since the "Soft Paths" land ethic can't be taught to dogs, the burden of responsibility lies with the judgment of their owners.

The "Soft Paths" ethic also applies to how you manage horses, mules, or llamas in the backcountry. But low-impact packstock practices are beyond the scope the authors attempted to cover in *Soft Paths*. Cole and NOLS agree that finding ways to reduce packstock impacts is an urgent priority.

*Soft Paths*' bravest assault on a sacred cow is when the authors question the tradition of the campfire, and nowhere else do the authors write more eloquently:

> *Like glowing embers, some ideas die slowly. It wasn't until the beginning of the seventeenth century that Johannes Kepler demonstrated that earth was not the center of the universe, and that all the fires beyond did not orbit our planet. Now, as we move even further away from human-centered beliefs, we shake our heads as we realize how long our forebearers stubbornly hung on to them. Yet even though we like to believe we are more sophisticated today, we're reluctant to lose our identity with fire itself. When we hike into the mountains or canoe a river, we move closer to our campfires as night falls. Campfires warm us, cook our food, or simply make us feel secure, stirring something deep within. They have a hold on us, refusing to burn out, even as they once held back the darkness of night long ago.*



*Continued personal freedoms, such as the ability to travel in wilderness with dogs, depends on good judgment and the determination of people to make sure their actions conform to a wilderness land ethic.*

*Snow during the summer in alpine areas, or in winter, provides an impact-resistant camping surface in areas that might otherwise be damaged by trampling. (NOLS/Will Waterman)*

In keeping with their approach not to make grand generalizations, let alone rules, Cole and Hampton don't suggest campfires should be banned, but that they should be built only with more thoughtfulness and understanding. They challenge the traditions of ringing a fire with rocks or building it in a pit, and suggest that often the opposite is best--building it on a mound of mineral soil. They address the problems of campfires in special environments, such as the white-bark pine forests of subalpine areas, where wood production is very low.

## Overly simplistic notions

"Any attempt to make it really simple is really going to cause problems," Cole said recently, while discussing the "Soft Paths" approach to education. Cole gives the problem of fire rings as an example where over simplification can be counter productive. Many wilderness rangers get instructions to break up and scatter all fire rings, but in many cases they can minimize impacts by leaving a few clean fire rings. A clean fire ring acts like bait to entice people to already-impacted areas and keep them from damaging new areas.

*You can eliminate potential impacts from human waste when traveling backcountry lakes or rivers by converting a surplus ammo box into a portable latrine. (NOLS/Will Waterman)*

"Another overly simplistic notion," Cole said, "is that desert and high elevations are fragile. Slickrock is the extreme example of a desert site resistant to camping impact." Snow is an impact-resistant campsite in alpine areas, but his research shows that even many alpine vegetation types "have great ability to absorb use."

Research reveals another over simplification in the idea that meadows are fragile, encouraging campers to use the adjacent forest communities. Cole's experiments with trampling damage show that many forest understories are more quickly damaged than meadows and are much slower to recover.

"Impact is a function of how readily plants are damaged and how fast they come back," Cole said, explaining that campsites should be selected with consideration of both factors.

## Ethics by example

Before writing *Soft Paths*, Cole and Hampton discussed the possibility of success in teaching ethics, and understood the difficulties of this approach to reducing human impacts on wilderness. But alternative ways to reduce impacts seemed short sighted.

NOLS' experience teaching over 30,000 students demonstrated that teaching a wilderness land ethic can be accomplished. But spreading the ethic to millions of people not captive to a NOLS instructor is a more difficult matter.

"NOLS' goal is to be the best teachers of wilderness skills that protect both the people and the land," Hampton said, further explaining their philosophy on environmental education. "We teach teachers, who teach by example."

The "Soft Paths" partnership between NOLS and Forest Service Research expanded to the National Forest System and other land management agencies when the "Leave No Trace" memorandum of understanding was signed in 1991. NOLS instructors became the headmasters and the Soft Paths book and video became aids to teach master instructors who will in turn teach trainers.

Under the "Leave No Trace" education strategy, NOLS instructors will teach the "Soft Paths" land ethic to agency people who will train wilderness rangers and seasonal workers that have frequent contact with wilderness users.

As Cole and Hampton point out in their book, low-impact practices require commitment, time and energy. With example as the primary teaching method, it is imperative that agency employees understand and practice a wilderness land ethic. For those responsible for teaching by example, living the land ethic is as much a part of the job as maintaining trails or packing out litter.

*Wilderness Ranger Kim Corette completes a campsite inventory to monitor human impacts in the Bob Marshall Wilderness in Montana.*

When successful, and high-impact behavior changes to become consistent with the "Soft Paths" land ethic, reformed wilderness abusers will likely never know that their more-thoughtful behavior is a result of research application.

## More information

Hundreds of copies of the book and video have already been distributed to National Forest Supervisor's and District offices. When the video was released, NOLS sent copies to all major conservation and environmental organizations in the United States.

Group showings of the video can usually be arranged by calling the closest National Forest office.

The video may be borrowed from the NOLS free-loan video library by calling Sierra Adare at 307-332-2794.

# Managing for salmonid habitat

by Elaine Loopstra, for Pacific Northwest Station

The annual wholesale market value of salmon products in the Western United States and Canada is more than $1 billion. Add to that the estimated $160 million spent on salmon sportfishing and the traditional values of subsistence fishing, and an extremely valuable resource is at stake.

That value has not always been recognized, however; over much of the past century, resource use has focused on maximizing single commodity production with little regard for impacts on other resources, especially fish habitats. For instance, starting in the mid-1800s, the vast grasslands of the Western United States were put to use for livestock grazing. By the 1920s, overgrazing was recognized as a serious concern, and eventually, by the 1960s, grazing allotments became accepted practice. But only in the last 20 years have the impacts of livestock grazing on salmonid habitat gained the attention of resource managers.

Why has if taken so long to recognize, and then properly manage, the impacts of resource use on salmonid habitat? Many reasons are involved, from economic to political, but one of the most essential factors has been lack of knowledge: managers simply have not had ready access to the information needed to understand and provide for salmonid habitat protection. A solution to this problem is now available. Dr. William R. Meehan, a research fisheries biologist with the Pacific Northwest Research Station, has coordinated and edited a new book, *Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats*. Published by the American Fisheries Society, the 751-page book reflects the complexity of salmonid habitat management. Contributing authors represent expertise in many disciplines, from basic information on salmon life histories, to the impacts of natural events and land-use activities, to habitat protection, restoration, and enhancement. In addition, the authors have cited nearly 2,000 references—many of them hard-to-locate reports of natural resource agencies. Says Meehan, "The information was scattered. There's a lot of it out there, but to get a hold of it was a big chore." That's an understatement: Meehan spent 5 years coordinating, writing, and editing the book.

*Freeze-core sampling reveals streambed gravel types and sizes; this information is needed to identify spawning gravels.*

Meehan's book treats in detail the direct and indirect effects of logging, forest chemicals, silviculture, timber transportation and processing, livestock grazing, mining, road building, recreation, and natural events on salmonid habitats. The following excerpts summarize some of these effects.

## Many limiting factors

"All salmonid species require relatively pristine freshwater habitats during part or all of their life cycles, and they need several kinds of habitat—for spawning, incubation, and rearing—during their lifetimes. Management of forests and rangelands can affect all these. Before the effects of resource management on fish habitat can be measured, we must have a thorough understanding of how the physical, chemical, and biological components of a stream system interact to form and control the habitats of salmonids.

"The stream and terrestrial ecosystems are closely linked. The flow of water, sediment, nutrients, and organic matter from the surrounding watershed shapes physical habitats and supplies energy and nutrient resources for the stream community. Riparian vegetation strengthens streambanks, contributes woody debris, and governs the influx of light and organic matter to the stream. Energy from sunlight and organic matter flows into, through, and out of the ecosystem; by processing these inputs, the stream community obtains energy for activity, growth, and reproduction.

"Salmonid habitats are products of the geology and soils, topography, vegetation, climate, and hydrology of a watershed. For the most part, these watershed characteristics remain fairly constant, as does the productivity of the aquatic habitats. Any change in these conditions, however, can bring about changes in sedimentation, cover and protection, water temperature, or nutrient and oxygen supply that may greatly affect fish production. Such changes may be caused by human activities, such as logging, road construction, livestock grazing, and mining, or by natural events, such as floods, mass soil movements, wind, and fire. The responses of salmonid populations to these changes differ with species, life stage, season, and geographic location, thereby complicating the management of fish resources."

## Natural events

"Changes in weather are the primary causes of changes in hydrologic processes. Floods can cause heavy sedimentation of streambeds and damage to channels, and can reposition the large woody debris that helps form pools, provides cover for young fish, and releases nutrients for stream productivity. Heavy rains can saturate soils and contribute to mass soil movements, or landslides. When earthflows reach streams, they bring large quantities of sediment and may scour the stream's spawning gravels and protective cover. Farther downstream, gravels and the fish embryos they contain become smothered with sediment, and habitats used by invertebrate organisms, the primary food for rearing salmonids, becomes degraded. On the other hand, abnormally low streamflow can restrict movements of fish and reduce the amount and quality of rearing habitat; shallow and slow-moving water usually is warmer as well.

"Wind and fire can destroy trees and disturb root masses, leading to slope failure and stream sedimentation. Fire can also alter the nutrient properties of the soil and can change nutrients available to streams. Destruction of the riparian vegetative canopy by wind or fire opens up streams to increased solar radiation, which can be either harmful or beneficial depending on the degree of change."

## Land-use activities

"Although land-use activities themselves may differ widely, the environmental alterations they produce generally affect fish habitats in similar ways. The effects of increased sedimentation on spawning gravels, for example, will be the same whether the sediment resulted from road construction, logging, mining, or livestock grazing. The same is true for other habitat variables such as water temperature, quantity and distribution of instream cover, channel morphology, and dissolved oxygen concentration.

"The effects of timber harvesting and silvicultural treatments (planting, thinning, burning, mechanical site preparation, and application of chemicals) on stream ecosystems are complex. These activities can influence the productivity of salmonid habitats both positively and negatively, which illustrates that the terrestrial and aquatic ecosystems must be managed as an integrated whole.

*Fish ladders, such as this one at Margaret Lake in southeast Alaska, are being evaluated as a method of salmonid habitat enhancement.*

"The principal consequences to aquatic systems of timber felling and yarding are changed rates of sediment and nutrient delivery and altered levels of temperature and dissolved oxygen. Prudent managers strive to minimize soil exposure and compaction, identify and avoid slopes that are at or near their stability thresholds, and maintain vigorous root networks. In addition, the value of maintaining a buffer strip of streamside vegetation to ameliorate the direct effects of logging activities has been well documented, and often the only way to avoid extensive damage is to avoid working in the riparian zone altogether.

"Toxic chemicals such as pesticides, fertilizers, and fire retardants, can affect salmonids directly, if they contact the fish, or indirectly, if they reduce the amount of riparian cover, decrease the abundance of insects that fish eat, or otherwise change fish habitats. Once chemicals enter the water, they may bioaccumulate throughout the food chain from bacteria and algae through invertebrate animals to fish. Potential direct and indirect effects must be carefully considered when chemical applications to a watershed are planned.

"Forest transportation systems can harm salmonids and their habitats because of the sediments they release to streams. Sediment generated by road construction reaches streams through surface erosion and mass movements of destabilized soil, and the effects can be dramatic and long-lasting. Bridges and culverts can block fish migrations; one poorly designed and installed culvert can affect the fish population of an entire stream drainage. Thorough reconnaissance, good planning, and wise route selection are the keys to minimizing the impacts of roads on streams.

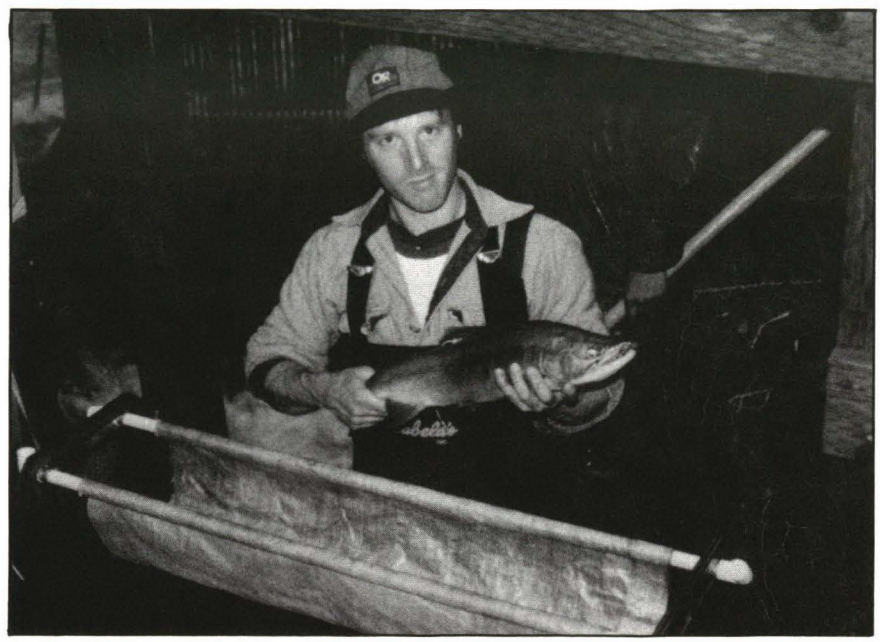
"Wherever livestock grazing occurs in western North America, it poses a potential threat to the integrity of salmonid habitats. Grazing impacts such as upland erosion, loss of riparian canopies, and breakdown of streambanks can degrade streams, riparian environments, and fish populations. Research has shown that aquatic ecosystems are resilient and can restore themselves over time if properly protected under intensive livestock management programs. The challenge is to identify and develop grazing systems that are compatible with local aquatic habitats and to persuade landowners and livestock managers to implement them.

"Mining can pollute streams and lakes by releasing suspended and bed-load sediments, toxic heavy metals, and acids, and it often causes changes in stream channels and water flow. Mitigative techniques for mining are like those for other activities that disrupt lands and streams, and operations should be planned from the beginning with pollution control and environmental recovery in mind.

"Fishing is a major recreational use of lakes and streams, and together with many other activities—swimming, boating, hiking, riding, camping—can damage riparian and aquatic habitats. The most effective control of such damage lies with managing access to streams and the concentrations of people along them. Planning and managing recreation require a multiresource perspective if aquatic habitats are to be protected and if user conflicts are to be prevented or resolved."

## Good planning is the key

In *Influence of Forest and Rangeland Management on Salmonid Fishes and Their Habitats*, the authors stress that a good fisheries or fish habitat management program should consist of three major components: planning, implementation, and evaluation. According to Meehan, the planning stage may well be the most important part of the management process. Potential users of the fisheries resources, as well as users of other resources influenced by the management program, should be brought into the planning process at its beginning to ensure that support for the program is established and will continue throughout its implementation.



*Biological Technician Glen Stanley holds the first adult sockeye salmon to return to Margaret Lake via the fish ladder.*

Implementation of rehabilitation and enhancement projects over the past 50 years has, through trial and error, resulted in habitat improvement techniques that can significantly increase the abundance of salmon and trout. But according to Meehan, "The basic premise for any fisheries or fish habitat management program should be that protecting the habitat from any management effects that would degrade it is preferable to mitigating the effects or rehabilitating the habitat after resource damage has occurred." Meehan emphasizes, "Protection of aquatic habitats should be the primary goal of resource managers."

Finally, evaluation should be an integral part of most habitat improvement projects. Stream improvement techniques would evolve faster if more projects were thoroughly evaluated and if more evaluations were made accessible to others.

## An evolution of ideas

In the past twenty years, several changes have had major impacts on how lands are managed for multiple resource values, especially fish habitat:

- increased concern by interest groups and the public to protect resources
- recognition by land managers and the public that land can and should be managed for resource complexes rather than for single commodities
- establishment of environmental protection laws at all levels of government throughout the United States and Canada
- increased knowledge of salmonids and their habitat needs through research

Meehan summarizes by saying, "During the last 20 years or so, as the great value of fish and other wildlife has become apparent, and as biologists have learned more about the detailed habitat requirements of salmonids and other animal species, the management of public natural resources has begun a fundamental evolution away from maximization of single resources toward optimization of resource complexes. This book is a product of that evolution and, I hope, will reinforce it."

*Influences of Forest and Rangeland Management of Salmonid Fishes and Their Habitats*, American Fisheries Society Special Publication 19, can be purchased from AFS 5410 Grosvenor Lane, Suite 110, Bethesda, Maryland 20814-2199 for $68.00 ($54.00 for AFS members). A limited number of copies are available to Forest Service fisheries managers through Bill Meehan, Juneau Forestry Sciences Laboratory, 2770 Sherwood Lane, Suite 2A, Juneau, Alaska, 99801, (907) 586-8811.

# Predicting the demand for grazed forages

by Rick Fletcher
Rocky Mountain Station

Forage is vegetation available for consumption by herbivores. The management of forest land, rangeland pasture, hayland, and cropland, is critical to the supply of forage. An analysis of the present and anticipated uses demand or, and supply of, the renewable resources of forest, range, and other associated lands is required of the Forest Service in the Renewable Resources Planning Act of 1974. Anticipating the supply and demand of range forage is one component of this analysis.

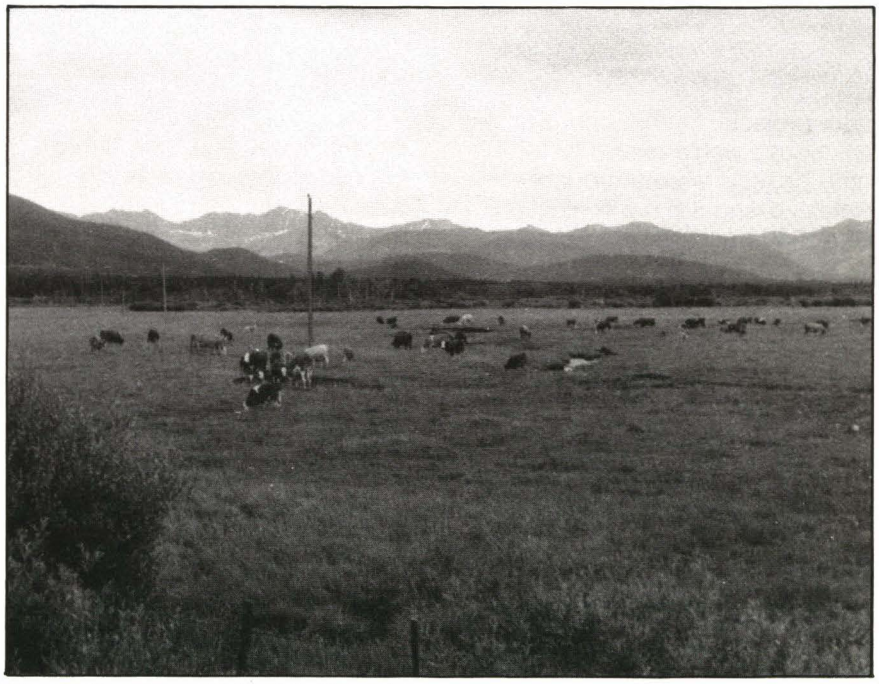
The major domestic users of grazed forages in the United States are beef cattle and sheep. In 1986, there were nearly 40 million beef cows and 7 million breeding ewes. Other kinds of livestock such as dairy cattle, goats, horses, and hogs use grazed forages, but their consumption appears to be less than 5 percent of the total consumed in the United States.

Grazed forages are produced on deeded nonirrigated range and pasture land, deeded irrigated pasture, publicly owned grazing land, and cropland. The price of forage from publicly owned grazing land, such as Forest Service land and land administered by the Bureau of Land Management, is set administratively. The price for forage from private lands is not usually determined by competitive bidding within a market system because this forage is often produced and consumed within the farm or ranch enterprise. Without an observable market for most of the forage consumed, the national demand for forage is difficult to analyze in terms of the traditional supply/demand equilibrium analysis of commodities.

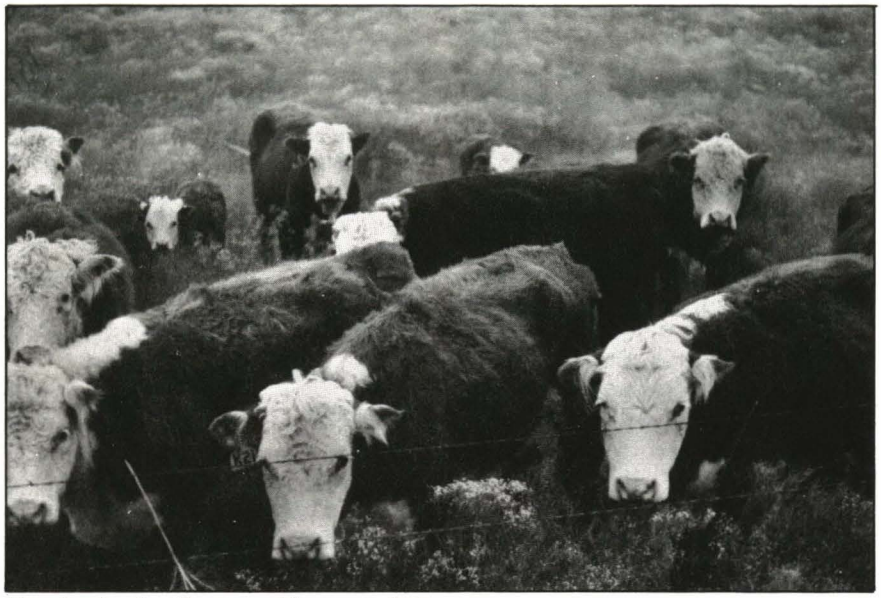
The Rocky Mountain Station has recently issued a report analyzing the projected consumption of grazed forage in the United States as derived from the demand for livestock. Range Scientist Linda Joyce, who helped author the report, explains that the demand for livestock is a function of society's demand for market commodities such as meat, hides, wool, and secondary products such as pharmaceuticals. "For this analysis of forage, the future supply and demand for meat was developed using the NIRAP model (an equilibrium modeling system of the agricultural sector) and a set of assumptions concerning population, economic conditions, and future meat consumption," she says.

## Role of grazed forages

The amount of grazed forages consumed is a function of total livestock numbers, the distribution of these numbers across the United States, and the distribution of livestock within segments of the beef cattle or the sheep industry.



*Livestock grazing in North Park, Colorado.*



*Breeding herds utilize grazed forage as their base feed supply.*

The structure of these industries is influenced by the general economy as well as the financial condition of the livestock industry.

Expanding cattle and sheep numbers increase the consumption of feed, including grazed forages. The general trend, until recently, has been an increasing U.S. cattle herd. Cattle numbers peaked nationally at over 130 million head in 1975 and since then, have dropped to levels similar to the 1960's. Sheep numbers peaked in 1942 at about 56 million head but dropped to 10.3 million head in 1987. Since 1960, the trend has been downward. The large decrease in sheep numbers has significantly reduced the demand for grazed forage even though large tracts of grazing area have been converted to recreation or other uses.

Beef cattle are found in all regions of the United States except the extreme Northeast. Although sheep are found over much of the United States, rangeland in the Pacific North, the California, the Northern Rocky, and the Southwest Regions have attracted most of the nation's sheep production.

## Industry structure

The beef cattle industry can be divided into three segments; first the beef breeding herds which produce calves, then stocker cattle, and finally, fed beef. Breeding herds and stocker cattle are direct consumers of grazed forages. Fed beef require little grazed forage but, as the final step in the beef production process, can influence the final product, and thereby, can have an important influence on the demand for grazed forage.

Imports of cattle from Canada and Mexico can contribute to the demand for grazed forage in the United States. Between 1960 and 1986, the number of imported cattle ranged from 1,314,058 head in 1986 to a low of 380,622 in 1975. This number of cattle consume large amounts of both forage and grains.

The sheep industry can be segmented into breeding herds and fed animal production. Like cattle operations, the sheep breeding operations demand the greatest amount of grazed forages.

## A look at financial conditions

"The decline in farm real estate values in the 1980's created serious financial problems for many livestock producers," says Joyce. "Lower real estate values have reduced the equity position of most ranchers and made it more difficult to obtain investment and operating capital. In 1986, 59 percent of beef, hog, and sheep farms had a negative net cash farm income," she explains.

Cattle and sheep businesses have historically been only marginally profitable. Low historical returns to the cattle business have probably been a significant factor in recent reduction in cattle inventories. Sheep have been fairly profitable since 1983 due to favorable lamb prices.

The annual average beef marketing margins, between farm and retail, as a percent of total retail value, have ranged between 31 and 43 percent during the years 1970 through 1990. Margins narrow when beef supplies are down and increase with large supplies.

The seasonal demand for forage is directly related to the type of livestock enterprise, as well as climate and management. The seasonal supply of range forage is a function of climate, management, land ownership patterns, and land use patterns. "Balancing the seasonal demand with available forage through the combination of feed sources makes successful cattle and sheep enterprises," Joyce says. Management activities can alter the seasonal demand for forage by shifting the type or kind of animal used within a livestock enterprise. On a national scale, these shifts within beef cattle and sheep operations can alter the total amount of forage used in the United States.

Within the beef industry, the objective of most stocker cattle enterprises is to produce animals of weight and condition that can move easily into a finishing program upon entering commercial feedlots. Different existing systems require different levels of management and capital inputs and different feed sources.

## Forage consumption

The consumption of grazed forage by livestock is difficult to estimate because this information does not exist in national inventories, forage is produced and consumed within the livestock operation, and forage use is a function of the type of livestock operation.

Joyce indicates that for this analysis, estimates of current grazed forage used by cattle and sheep are based on livestock enterprise budgets prepared by the Economic Research Service, Forest Service, and Bureau of Land Management. These budgets are based on a national sample survey conducted by the Statistical Reporting Service in which detailed estimates are made of feed consumption by type of feed and season of use. Feed use in the Forest Service and Bureau of Land Management budgets are based on agency billing records supplemented by information from producer panels.

Forages include deeded nonirrigated rangeland and pasture, deeded irrigated pasture, crop residues, and publicly owned grazing land. Joyce estimated the aggregate grazed forage consumption by beef cattle and sheep in the United States by expanding per head feed consumption in the enterprise budgets by the number of animals represented by each budget. These quantities are then reflected in a national total for each major source.

Beef cattle consumed 412 million animal unit months (AUMs) of grazed forages, and sheep consumed 19 million AUMs of grazed forages in 1985 for a total of 431 million AUMs nationally. Deeded nonirrigated grazing land provided 86 percent of the total grazed forage, followed by public grazing land with 7 percent, and crop residues with 5 percent. The remaining 2 percent was from irrigated pasture. Public grazing land was more important to sheep than to beef cattle, providing 28 percent of their aggregate annual forage consumption.

## Factors affecting future demand for grazed forage

Historically, grazed forage consumption has been closely correlated with changes in livestock inventories. Another set of factors pertain to the demand for meat, which is a function of the total U.S. population, per capita consumption, per capita disposable income, and the international market. These variables will probably continue to be important determinants of inventories in the future. However, just as the energy crisis in the early 1970s was not foreseen and had an unanticipated effect on all aspects of the U.S. economy including livestock production and meat consumption, future unanticipated events may have a greater impact on the livestock industry than any of the traditional factors. "The recent financial crisis in agriculture which has markedly impacted all sectors of agriculture was not even considered as a possibility 10 years ago," says Joyce. "Major political disruption in the world, unexpected population growth, adverse weather, or other phenomena may change the entire picture of future demand for grazed forage," she explains.

The demand for meat is a function of the total U.S. population and the per capita consumption of meat. Future growth in the U.S. population, as well as any changes in per capita consumption, will influence meat demand, livestock production, and consequently forage demand.

Beef has been the meat favored by U.S. consumers since the early 1950s when it surpassed pork.

When disposable income is relatively high, meat becomes a major food item and, in the past, average disposable income has been used as an indicator of likely future meat consumption within the United States. However, per capita disposable income in the United States has increased every year from 1968 through 1986, but the percent of disposable income spent on beef has declined steadily from 2.4 percent in 1979 to 1.5 percent in 1986.

Decreased beef and lamb consumption may reflect sociological factors such as a more health conscious public interested in low fat diets or lean meats, or shifts in consumer taste preferences away from beef. Also, societal changes, such as more working couples and single heads of households, have fostered a need for more convenience foods with short preparation time, meaning an increased consumption of food away from home. Meat packers are now making significant efforts to develop prepackaged meat portions, precooked products, shredded beef with sauces, and have recently developed a process to restructure high quality beef trimmings into fabricated steaks.

*The seasonal supply of range forage is a function of climate, management, land ownership patterns, and land use patterns.*

## Forage consumption projections

Projections of grazed forage consumption are based on projections of carcass beef and sheep prepared by the Economic Research Service (USDA). These carcass estimates are converted into beef cow and breeding ewe inventory projections. These inventories are then multiplied by grazed forage coefficients per head to estimate aggregate grazed forage consumption.

Disposable personal income is projected to increase nearly two times the 1986 level by 2030. Although this is critical in terms of the consumption of goods and services, the strong tie between disposable income and meat consumption appears to be weakening.

Joyce explains that the extrapolation of the historical trend suggests that per capita beef consumption could be as low as 50 pounds on a retail weight basis by 2030 compared with 75 pounds in 1987. Similar declines are suggested for per capita lamb consumption.

Joyce and her associates projected forage consumption for six major regions of the United States. The distribution of cattle in the Southwest, Northern Rocky, and Southern regions appears stable in that the trend over the 1974-87 period did not have a significant or large direction. These regions averaged 76 percent of the total beef cow numbers over the 1974-87 period with a coefficient of variation of less than 10 percent. In 1987, these regions accounted for 77 percent of the beef cows, and in 2030 these regions will still have about 77 percent of the cattle. These regions are traditional rangeland areas where cattle are tied closely to the permanent grazed forage base, which has been relatively stable in the past. The proportion of cattle in the Northern region declined while the proportion of cattle in the Pacific Coast states increased. The Northern region, which includes the major cropland areas of the Corn Belt, is expected to decline in relative importance for feeder cattle production. The trend has been toward specialized crop production in this region at the expense of beef cattle, and fed beef production has been reduced considerably in recent years. The Pacific Coast states are expected to carry a larger proportion of the beef cow inventory than in the past. These regions had 5.6 percent of the beef cows in 1987 and are expected to increase to 10.2 percent by 2030.

Estimates of regional grazed forage consumption by sheep are based on historical distributions of breeding ewe inventories. The Northern and Southern regions are projected to become relatively less important for sheep production by 2030 than in 1987. The Southwest and Northern Rocky regions are expected to continue in the future about the same as in 1987, while the Pacific North and California regions are projected to increase in importance.

## Implications

"Our projections suggest that beef consumption will increase at rates paralleling population growth," says Joyce. "Analyses of forage supply suggest that this future demand for grazed forages can be met by future supply. This analysis, however, does suggest a shift in the feed sources used in beef and sheep production, and a decline in the use of forage from public lands. This decline suggests increased forage production on private lands if the projected forage demand is to be met. Continued increases in forage production on forest and rangelands will depend on sustained management activities. Recent analyses of range improvement practices suggest that an improved livestock market will be necessary for the continued implementation of this technology," she says.

A critical assumption is the constant per capita consumption for beef, veal, lamb, and mutton. A decline in per capita use may cause a decline in the demand for grazed forages. In addition, a shift in preference for leaner meat may cause a shift in the relative contributions of different feed types and sources in the livestock production process.

Joyce notes that analyses like these are beneficial in determining the future demand for range forage. This future demand will interact with demand for range forage for other uses such as wildlife grazing and recreation. At present, this analysis is the only one at the national level addressing the future demand for range forage for any use. She is quick to note that further research is needed to expand this analysis to encompass alternative uses of range forage.

Additional information is available in the publication *Factors Affecting the Demand for Grazed Forage in the United States*, General Technical Report RM-210, available from the Rocky Mountain Station. Range Scientist Linda Joyce can be reached at the Rocky Mountain Station, 240 West Prospect Rd., Fort Collins, Colorado 80526-2098, (303) 498-1856.

# Pheromones help save Torrey pines

by David Ross Berson, for Pacific Southwest Station

An innovative strategy for combating a bark beetle infestation is credited with saving one of the nation's rarest species of pine tree from devastation. The USDA Forest Service program utilized synthetic pheromones to lure ips beetles into traps at Torrey Pines State Reserve near San Diego.

Officials and patrons of the scenic California park have been watching with horror as hundreds of the picturesque Torrey pine trees were killed by the bark beetles. Looking for alternatives to unnatural measures to deal with the infestation, the park management consulted with Dr. Patrick Shea, Principal Research Entomologist of the Forest Service's Pacific Southwest Research Station at Albany, California. Under Dr. Shea's direction, the "trap-out" strategy was chosen and appears successful after five months.

The Torrey pine is a beautiful and comparatively delicate species with a life span of only about two hundred years. The 120 acre stand in the 1,750 acre state reserve along the Pacific coastline near La Jolla, California is the only native Torrey pine stand on the United States mainland. The only other natural community of the trees is located on Santa Rosa Island, off the coast of Santa Barbara.

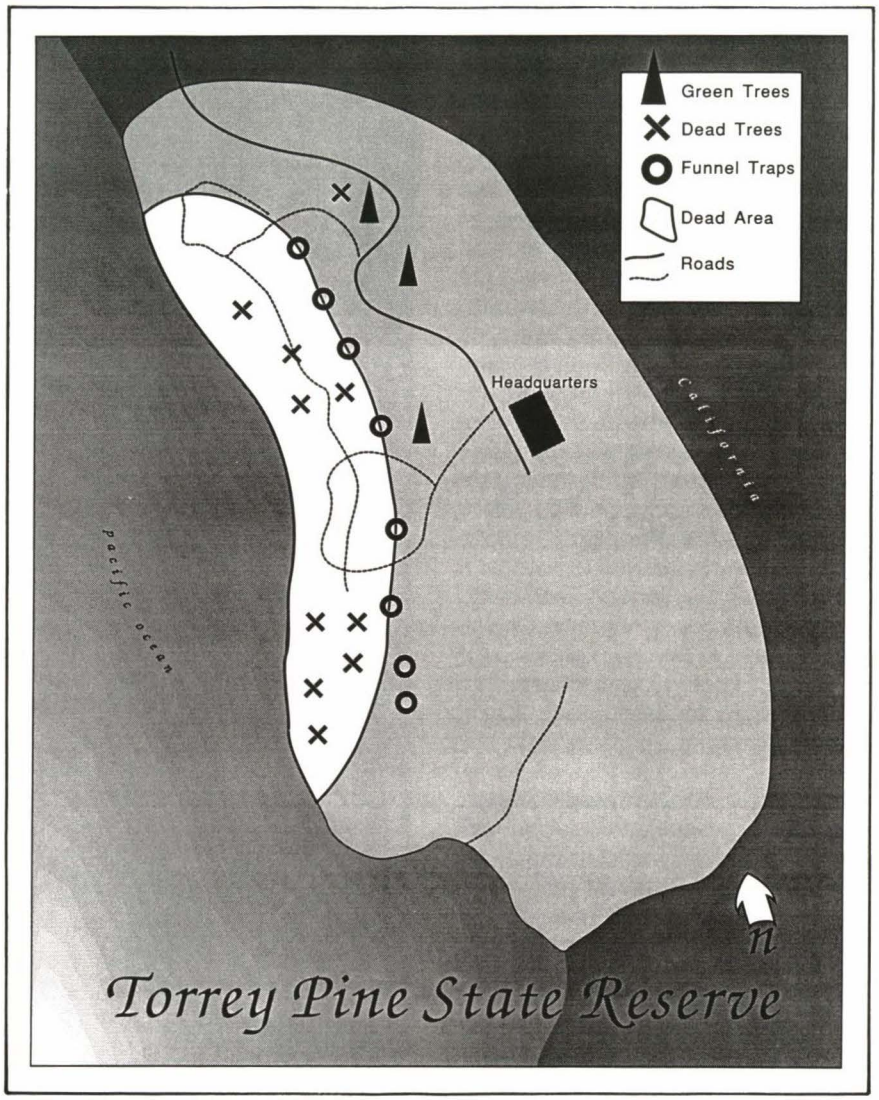
*Lindgren funnel trap containing aggregation pheromone used to trap Bark Beetles.*

## The bark beetle attack

The ips beetle (*Ips paraconfusus*), also known as the California five spined ips, is native to the United States and limited to California and some small areas of Nevada. The quarter-inch long, winged insect normally feeds on downed trees and is not often considered a dangerous killer of trees.

For a successful attack to take place, the bark beetle uses pheromones. Pheromones are chemical substances released into the environment by one individual that influences the behavior of other individuals of the same species. The adult ips beetle excretes alluring pheromones through a bio-enzymatic pathway for two basic purposes, to aggregate other ips for mass attack of trees and to attract mates for reproduction. At Torrey Pines the ips uncharacteristically attacked live trees. After mating between the bark and the wood, eggs are laid, and emerging larvae feed on the cambium or soft tissue of the trees.

Noting that a fierce 1988 storm had blown down many trees in the Torrey State Reserve, Dr. Shea theorized that with an unusually large food supply available, the bark beetles had multiplied In untypically large numbers. With increased numbers and appetite, the ips population had moved from the downed material to feed on living trees, causing unacceptable tree mortality. The pines, whose immune systems had been weakened by years of drought in California, quickly succumbed to these attacks. Some trees were effectively killed in a matter of a few hours after an ips onslaught.




*Map showing placement of baited funnel traps for "trap-out" strategy.*

By 1990, the beetles had killed more than 12 percent of the park's 7,000 Torrey pines. Park visitors were crushed when they saw the devastation along the park's most popular trails. Recounts the park's Supervising Ranger Bob Wohl, "The most beautiful, stately and windswept trees seemed to have died first. They were some of the favorites of both the public and the staff. People pleaded with us, 'What can you do? What are you doing to our favorite trees? How can you stop this infestation?' There was a tremendous feeling of loss and sadness."

"The desire and the need to do something became pressing and urgent. When we got up to nearly 650 dead trees after three or four years of infestation, it was of paramount importance to find a non-intrusive way to get the bark beetle out of the nature reserve," says Wohl.

Noting his initial examination of the damage, Dr. Shea recalls, "In 25 years experience as a forest entomologist, I have never seen this insect kill with this intensity. It's usually just a spot of trees here and there. But this attack was on a very extensive area."

The ips beetle had been a nuisance at Torrey Pines in the past, but these incidents only involved a few trees, and the beetle attack was eventually turned back by the trees' natural defenses," explains Bill Tippits, Senior Resource Ecologist for the California Department of Parks and Recreation. "Then the ips population returned to the very low level, typical of their numbers in the park."

When the new infestation grew serious, Tippits and his colleagues considered several unattractive options. Employing insecticides was rejected as too toxic and indiscriminate. Watering the Torrey pines to strengthen their immune system was considered unfeasible for so large a stand. Thinning the stand with a logging operation was "unacceptable from an esthetic point of view as well as the fact that this is a state reserve and we try to manage using as natural a process as possible," says Tippits. "We also thought about clearing out a large amount of the underbrush, which also competes for moisture with the Torrey pines. But this would have also been difficult to carry out and also wouldn't have been reflective of a natural management strategy."

## The "trap-out" strategy

Dr. Shea suggested a strategy of using synthetic pheromones as bait to lure the ips beetle out of the infested portion of the stand into traps. Tippits was familiar with pheromone research involving bark beetles conducted by Dr. Tim Paine of University of California Riverside, and although experiments had yielded inconclusive results, he agreed that Shea's idea was worth trying.

Shea reasoned that because the stand was isolated, with no other Torrey pines within a one mile radius, it was ideal for a "trap out" strategy. Beginning in May of 1991, 10 sets of three black Lindgren funnel traps, were strategically placed every 60 to 80 yards in a line approximately 800 yards long between dead trees and those still living.

The aggregation pheromone of the California five-spined ips was placed in each trap. Plastic packets encased the aggregation pheromone consisting of the following terpenoid compounds: ipsenol, cis-verbenol, and ipsdienol, as manufactured by Phero Tech Inc., of British Columbia, Canada. The pheromone liquid evaporated, giving off its turpentine-like odor, at a measured rate over a period of some 55 days. The cost of the materials for the project was $3000.

In addition to the aggregation pheromones, anti-aggregation pheromones contained in small release devices were attached to trees in the green, healthy portion of the Reserve, parallel to the funnel traps. These consisted of a mixture of verbenone and ipsdienol. Anti-aggregation pheromones are naturally released by beetles when feeding and when oviposition sites are all occupied.

In effect the beetles were being sent a double signal, called "push-and pull effect" by Dr. Shea. While the aggregation pheromones were pulling the ips toward the traps, the *anti*-aggregation pheromones were pushing them away from the green uninfested stand.

Park staff visited the traps weekly and inspected the catchment cups attached to the bottom of the funnel traps. All trapped beetles were removed and placed In a freezer for identification and counting by Dr. Shea.

The results were both immediate and dramatic. At the outset in early May, 33 trees were found to be recent victims of infestation. The trees were fading to a reddish color and still contained maturing larvae. After one week of trapping, 13,000 ips were captured. During the first nine weeks of trapping, more than 130,000 ips were removed from the funnel traps. Most importantly, only one additional tree was attacked after the trapping began. The number of trapped beetles eventually fell to about 100 per week.

"I can't say with any statistical probability that our trap-out program has done the job, but we cannot come up with any other reasonable explanation of why the mortality has been reduced to just one tree. The beetles should have moved through the stand, but they haven't," says Dr. Shea.

Tippits says a prescribed burn in the main tree mortality area will soon be initiated to clear out some of the shrubbery and dead material. Then planting will be carried out to supplement the Torrey pine stand.

Fortunately, prior to the devastation at Torrey Pines, the Forest Genetics Research Group/Center for Conservation of Genetic Diversity of the Pacific Southwest Research Station, had conducted a seed collection from 145 Torrey pines at the Reserve to facilitate long-term conservation. The availability of these seeds means that the groves restored at Torrey Pines will germinate from the same genetic stock that produced the trees lost in the bark beetle infestation.

## Future research

Dr. Shea sees much potential in using pheromones for combating bark beetle infestations. "The Torrey Pines operation was not an experiment, but rather an operational demonstration of this particular strategy. We have shown for the first time in the United States that the trap-out strategy can be effective given this set of conditions, the small, isolated, and contained stand, uncomplicated by additional beetle emigration. Therefore, in terms of manipulation, the strategy was a much easier proposition at Torrey Pines than a very large stand of many thousands of acres."

"Torrey Pines has been a nice observational situation for scientists like me, but it could become very helpful to people who need to manage forest lands. Now what we want to do is take this experience and try to apply it in other areas where ips and other bark beetles are responsible for extensive mortality. It might be successful in plantation and campground situations, high-value stands and unique locations like Torrey Pines," says Dr. Shea. Additional research is underway in Alaska, Montana, and other parts of California that will utilize pheromones to control bark beetles.

"We are just beginning to learn how to use pheromone systems with bark beetles and other insects for pest management purposes, but we have come a long way in the last twenty-five years. Now it's time to increase our development of strategies that use pheromones to manage mortality caused by bark beetles.

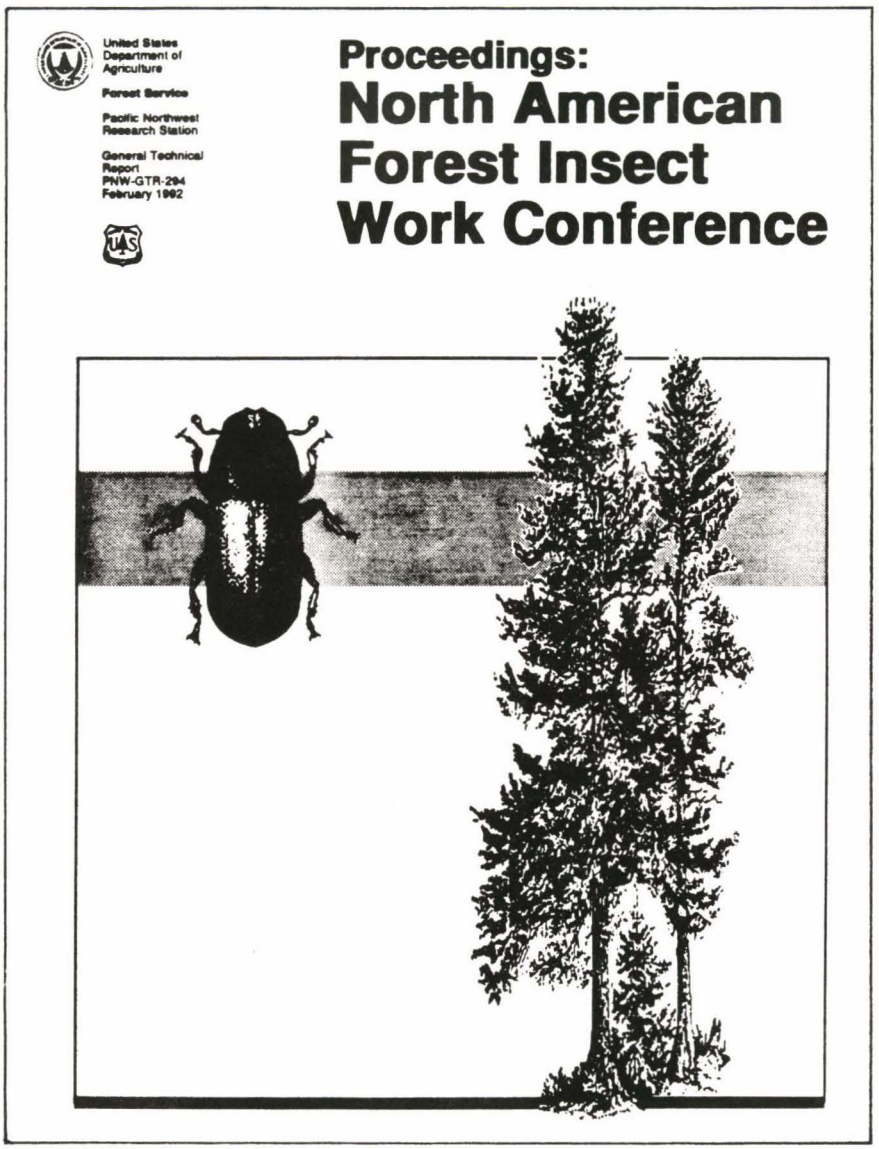
For additional information about this project contact: Pacific Southwest Research Station, Chemical Ecology of Forest Insects (RWU-4502) P.O. Box 245, Berkeley, CA 94701.

# New from research

## Proceedings from the North American forest insect work conference

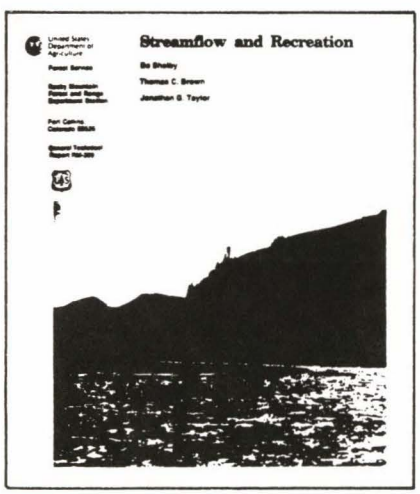
A proceedings of a conference held to stimulate interaction among people working in areas of forest protection and silviculture and on issues of national and international concern relative to forest insect and disease management, education, and research have been published. National issues addressed were forest productivity, stewardship, biological diversity, and new perspectives, and how these issues affect environmentally sound management of forest pests.

Request *Proceedings: North American Forest Insect Work Conference*, General Technical Report PNW-GTR-294, from the Pacific Northwest Research Station.



# Streamflow and recreation

The quality of water-dependent and water-enhanced recreation such as fishing, boating and camping is intimately tied to streamflow. Yet the relationship between streamflow and recreation quality is not well understood or documented. A recent paper reviews what is known about this relationship and the methods used to study it. Legal and administrative issues are also reviewed, focusing on how to best protect flows for recreation.



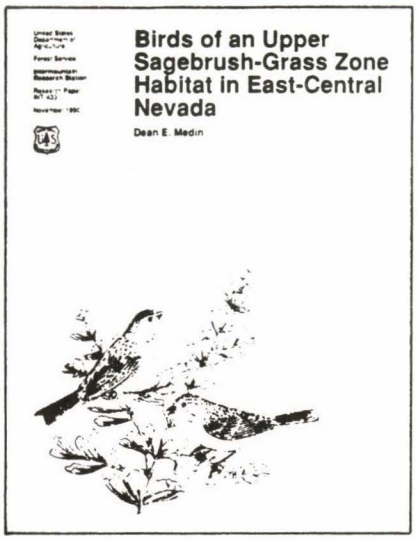

For a copy of *Streamflow and Recreation* request General Technical Report RM-209 from the Rocky Mountain Station.

# Birds of Nevada's high sagebrush

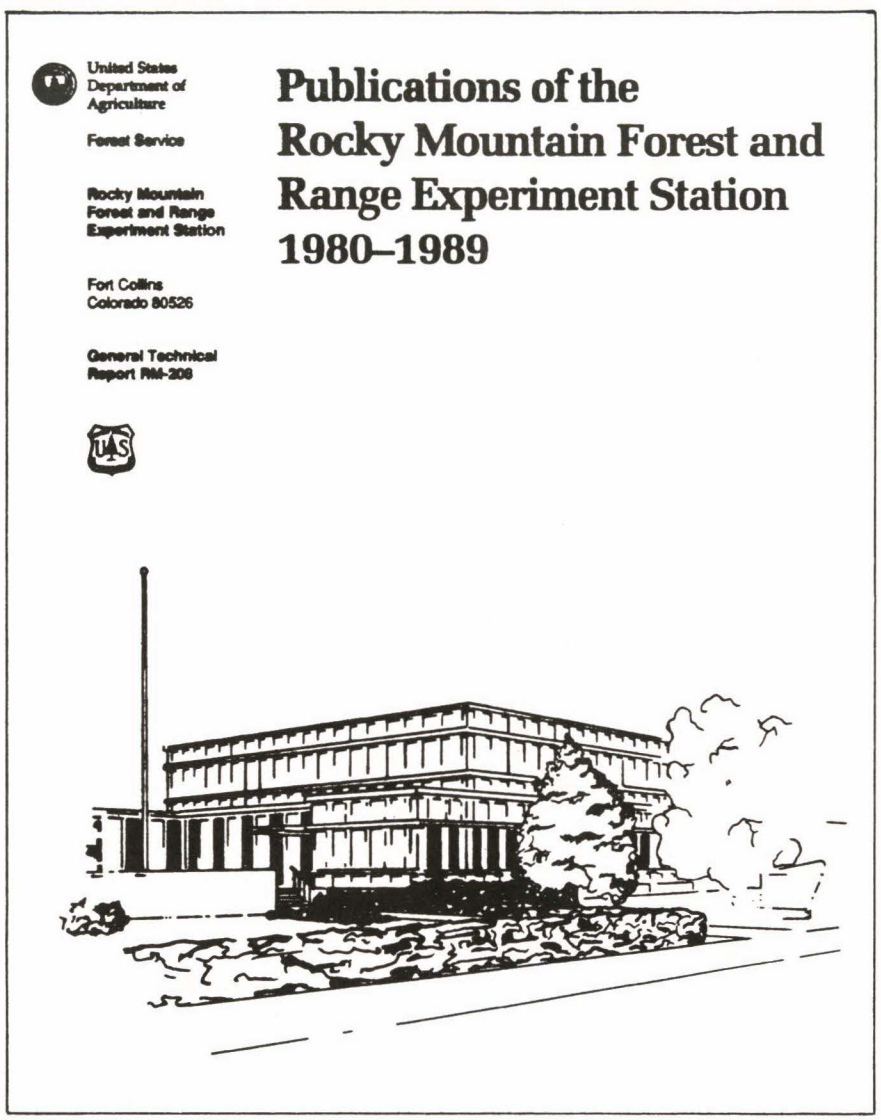
Research in the upper sagebrush-grass zone of Nevada's Snake Range, revealed that sagebrush community types in this zone are some of the most valuable for non-game breeding bird habitat in the Great Basin. Only the mixed conifer zone had greater bird density, but had fewer breeding species.

Brewer's sparrow and green-tailed towhee were the most common of the 25 species that bred in the study area.

Wildlife Biologist Dean Medin concluded that, because the mixed conifer and upper sagebrush-grass zones are the most physiognomically complex habitats, species richness and breeding bird densities are greater here than in habitats both higher and lower in elevation.




Request Research Paper, INT-433, *Birds of an Upper Sagebrush-Grass Zone Habitat in East-Central Nevada* from the Intermountain Research Station.




# Index of publications from 1980-1989: Rocky Mountain Station

A thorough index of all 2125 publications produced by the Rocky Mountain Station in the 1980's was recently compiled as a continuation of others which came before it. The index offers a handy guide to publications and lists them by author and subject. Entrys on each publication include: names of authors, title, date of publication, length, the source it appears in, and a brief synopsis of each report or article.

For a copy of *Publications of the Rocky Mountain Forest and Range Experiment Station, 1980-1989*, please request General Technical Report RM-208 from the Rocky Mountain Station.

# Regeneration of white spruce in interior Alaska

The seasonal and spatial patterns of dispersal of white spruce seed were studied from 1986 to 1989 in flood-plain stands along the Tanana River near Fairbanks, Alaska. Analysis of the 1987 crop showed that production of filled seed was strongly related to estimated production of total seedfall and unrelated to selected stand structural characteristics. A mathematical expression, developed to estimate dispersal of filled seed into clearcut openings, predicted dispersal between 10 and 120 meters from the edge of an opening. The pattern of wind during the seed-dispersal season was predictable and consistent with winds measured at the Fairbanks International Airport. The results give forest managers ways to increase natural regeneration of white spruce in interior Alaska.

Request *Dispersal of White Spruce Seed on Willow Island in Interior Alaska*, Research paper PNW-RP-443, from the pacific Northwest Research Station.

# Speed of seed germination in central Oregon ponderosa pine

The variation of speed of seed germination was investigated among ponderosa pine trees representing 225 locations in central Oregon. The results suggested that at least some of the geographic variation is related to the severity of summer drought. In general, germination speed was greater in locations with short, drought-limited growing seasons. Levels of geographic variation were highest in the region having the steepest precipitation gradients. Most of the variation occurred, however, within locations.

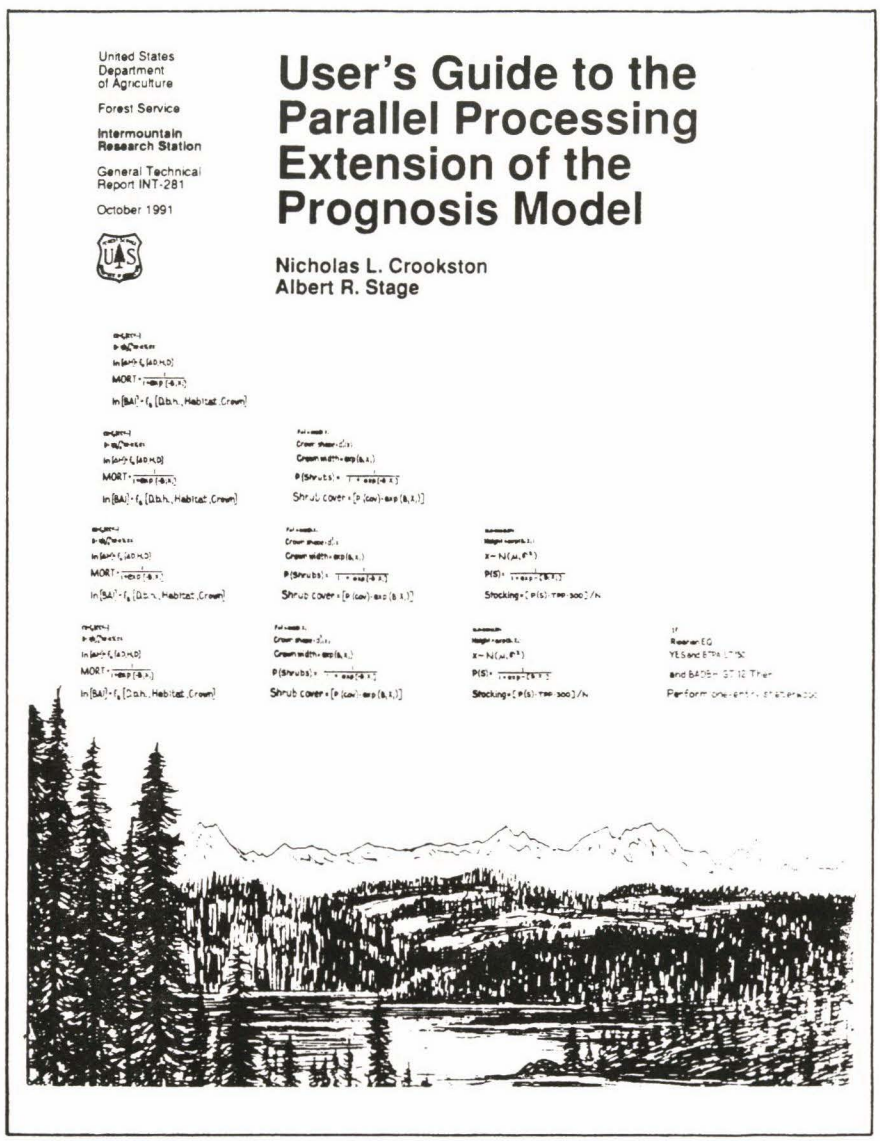
Request *Geographic Variation in Speed of Seed Germination in Central Oregon Ponderosa Pine*, Research Paper PNW-RP-444, from the Pacific Northwest Research Station.

# User's guide to the Parallel Processing Extension of the Prognosis Model

The Parallel Processing Extension to the computer model prognosis allows timber planners to simulate stand development simultaneously for a thousand stands for up to 400 years into the future. With the parallel processing capability, the system can simulate effects of contagious pests and management prescriptions that depend on conditions in surrounding stands.

Numerous policies and management alternatives can be evaluated in the same simulation.

Request General Technical Report, INT-281, *User's Guide to the Parallel Processing Extension of the Prognosis Model*, from the Intermountain Research Station.



# New Guide Identifies Landslide Hazards

*A Guide for Management of Landslide-Prone Terrain in the Pacific Northwest* is a handbook for agency, industry, and other personnel who are operating in areas with existing or potential slope stability problems, and is intended for use in coastal areas of Southeast Alaska, British Columbia, and the Pacific Northwest through northern California. It represents 30 years of Pacific Northwest Research Station (PNW) and cooperative research on landslide identification, hazard assessment, and impact on channel systems. Measures for control and management of unstable terrain are also discussed.

The guide is a cooperative effort of PNW, the B.C. Ministry of Forests (publisher), the B.C. Ministry of Environment, and the Canadian Division of Fisheries and Oceans. It is co-authored by Doug Swanston, Principal Research Geologist at the Juneau Forestry Sciences Laboratory, S.C. Chatwin and J.W., Schwab, B.C. Ministry of Forests, and D.E. Howes, B.C. Ministry of Environment.

Swanston is distributing copies of the book to Forest Service engineering, hydrology, and fisheries staffs throughout western U.S. states. The book is also available to state agencies, universities, industry, and other interested clients. Contact Doug Swanston, Juneau Forestry Sciences Lab, 2770 Sherwood Lane, Juneau, AK 99801, or call (907) 586-8811.

# Goats studied as chapparal shrub control method

As an alternative to conventional methods of using fire, machines, and chemicals to control unwanted brush, scientists studied the option of using Spanish goats to convert chaparral to herbaceous vegetation: a conversion which improves water yield, increases forage production, improves wildlife habitat, decreases fire hazard, and provides more aesthetically pleasing landscapes.

The study evaluated the four-year effect of Spanish goats on an Arizona site which hosts several different shrub communities but is dominated by shrub live oak. Specific study objectives were centered around determining the effects of goat-stocking rates on 1) the regrowth and survival of chaparral shrub species; 2) herbaceous vegetation; and 3) litter and soils. The objectives were tested with and without mechanical brush crushing techniques.

For a copy of the study and its results, request the reprint *Influence of Spanish Goats on Vegetation and Soils in Arizona Chaparral*, from the Rocky Mountain Station.

To order any of the publications listed in this issue of *Forestry Research West*, use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

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1) *Geographic Variation in Speed of Seed Germination in Central Oregon Ponderosa Pine*, Research-Paper PNW-444.
2) *Proceedings: North American Forest Insect Work Conference*, General Technical Report PNW-294.
3) *Dispersal of White Spruce Seed on Willow Island in Interior Alaska*, Research Paper PNW-443.
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3) *Streamflow and Recreation*, General Technical Report RM-209.
4) *Publications of the Rocky Mountain Forest and Range Experiment Station, 1980-1989*, General Technical Report RM-208.
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2) *Managing Wilderness Recreation Use: Common Problems and Potential Solutions*, General Technical Report INT-230.
3) *The Limits of Acceptable Change (LAC) System for Wilderness Planning*, General Technical Report INT-176.
4) *User's Guide to the Parallel Processing Extension of the Prognosis Model*, General Technical Report INT-281.
5) *Relative Corrosivity of Currently Approved Wildland Fire Chemicals*, Research Paper INT-437.
6) *Birds of an Upper Sagebrush-Grass Zone Habitat in East-Central Nevada*, Research Paper INT-433.
7) Other _____

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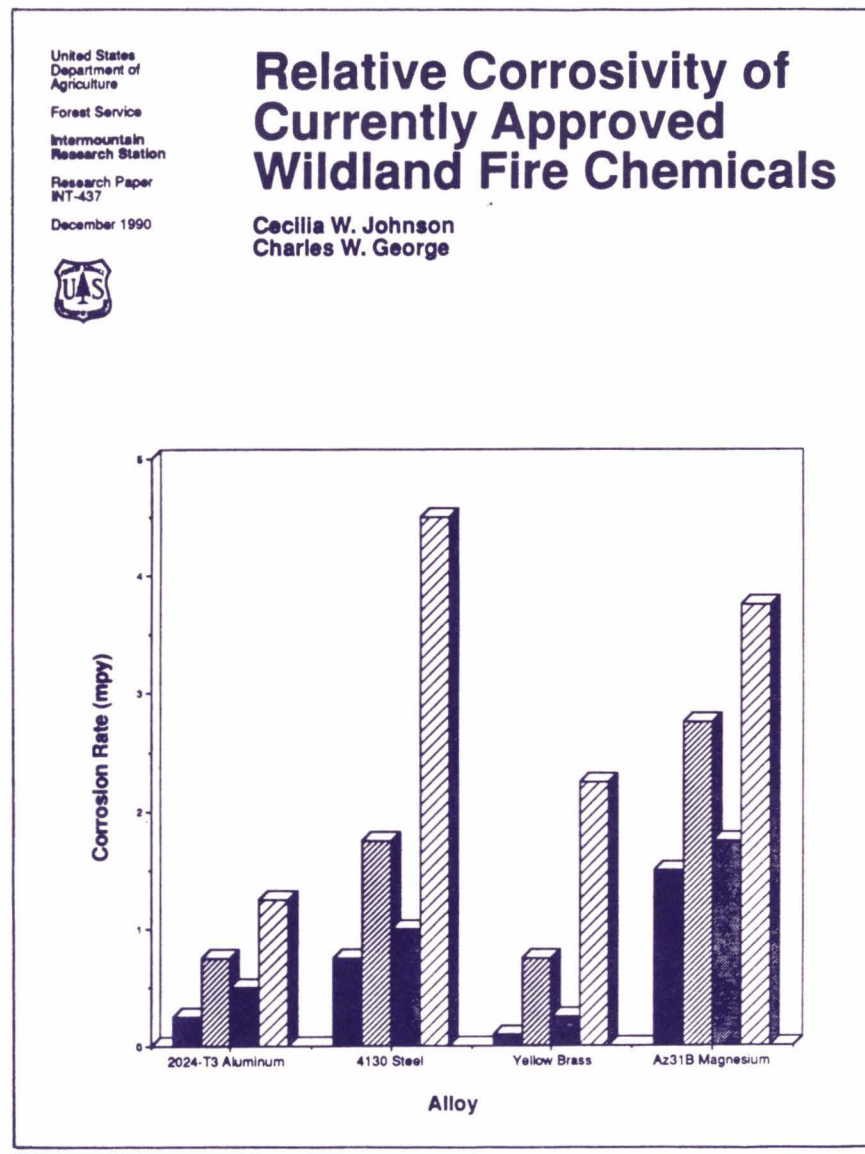
# Corrosivity of fire chemicals

The different kinds of currently approved fire-retardant chemicals have different degrees of corrosivity on tanks and other metal handling equipment, such as valves. Damage from some retardants on some metal fixtures can be severe.

Information from this research indicates when aluminum or stainless steel valves should be used rather than brass. It also suggests that if a loading base already has a large investment in brass valves, some chemicals might be more appropriately used at that base than others.

The publication also includes suggestions on detecting and minimizing corrosion before damage is too costly.

Request Research Paper, INT-437, *Relative Corrosivity of Currently Approved Wildland Fire Chemicals,* available from the Intermountain Research Station.



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